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Implications of an Air Force Budget Downturn on the Aircraft Industrial Base

An Exploratory Analysis

Mark V. Arena, John C. Graser, Paul DeLuca



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RAND Project AIR FORCE

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Preface

This report is an exploratory analysis of aircraft industrial base (AIB) implications that might result from the impending budget downturn faced by the U.S. Air Force. It seeks to address three questions:

- How is the current situation different from the downturn in the mid-1980s?
- What can we learn from prior industrial base assessments to inform upcoming decisions?
- What are the investment options for Air Force aircraft acquisition and how might they affect the industrial base?

In answering these questions, we draw upon existing research and use it to identify key strategic issues as the Air Force considers how to manage the AIB during the current budget downturn.

This research was completed in late 2012. At that time, Air Force planners faced the threat of sequestration—a mechanism that would result in significant and indiscriminate cuts to the defense budget required as part of the 2011 Budget Control Act. Sequestration was implemented for the fiscal year 2013 budget during the finalizing of this report in mid-2013. Regardless of the outcome of sequestration in future years, it is anticipated that the Air Force will have reduced financial resources going forward for the next several years. It is this challenging budget environment that sets the context for this report. The uncertain budgetary environment makes careful planning even more important—an objective this report hopes to inform. However, the discussion of investment options is always relevant—regardless of whether budgets are robust or thin.

The research reported here was sponsored by James Brooks, Deputy Director, Strategic Planning Deputy Chief of Staff for Strategic Plans and Programs, Headquarters United States Air Force (HQ USAF). The analysis was conducted within the Resource Management Program of RAND Project AIR FORCE as part of the project “Examining the Aircraft Industrial Base During Declining Total Obligation Authority: Implications for the U.S. Air Force and a Way Ahead.”

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Summary

The U.S. Air Force is facing a number of challenges as a result of the current defense budget downturn along with the uncertainty of its timing and magnitude.¹ This report focuses on the challenge of modernizing the Air Force's aircraft fleet while trying to sustain the industrial base with limited funding. Complicating this challenge is that the pattern of Air Force spending has shifted dramatically away from new aircraft procurement since the previous spending downturn. Moreover, the emergence of a competitor with significant technical and economic capability is another major difference from the previous downturn.

Therefore, there is a need for careful strategic management of investment choices—and this goes beyond just aircraft. The Air Force will first need to define its capability priorities that fit within budget constraints, then use those priorities to shape a budget strategy. We explore six different budget strategies for aircraft procurement: from a new high-tech fleet to sustaining and modifying the existing one. Each strategy under a constrained spending future results in challenges and issues for the industrial base. The Air Force will need to help mitigate industrial base problems that result from their chosen budget strategy—but some issues may be beyond their control. There are lessons from foreign acquisitions that the Air Force can leverage to avoid pitfalls. Most importantly, shortfalls in both industry and government skill bases can cause significant problems later during execution. Finding ways to sustain key skills during a spending downturn will be important for the future and potentially produce longer-term savings.

Finally, a few other observations that must be considered as the Air Force moves forward:

- The aircraft industrial base (AIB) could consolidate again, potentially morphing into sole sources (or sole-source teams) in many areas. This would require the Air Force to rethink how it works with industry and how it formulates acquisition strategy, as competition on individual programs might be infeasible.
- Military aircraft design and production requires some unique skills not found in the commercial aircraft segment and that are difficult to rebuild. While industry must manage these skills and has primary responsibility for them, the Air Force also has a critical role in ensuring these skills are preserved. Few new program starts are projected, so research, development, test, and evaluation (RDT&E)

¹ As of the finalizing of this report in mid-2013, Air Force planners face great uncertainty with respect to future budgets. Fiscal year 2013 did have mandatory reductions required by the 2011 Budget Control Act. However, cuts in future budget years remain uncertain.

- funds will be the primary lever the Air Force has to protect technical skills. The Air Force should consider devising a strategy that focuses the limited RDT&E likely to be available on technical areas that are not supported by commercial development.
- The Air Force must find ways to slow the progression of higher unit procurement costs and flying hour costs for new systems if it is going to be able to recapitalize/modernize effectively.

Acknowledgments

The authors thank James Brooks and Dr. Carl Rehberg, AF/A8X, for their helpful feedback, data, and perspective on many of the issues presented in this report. Their input greatly improved the quality and depth of this product.

We would also like to thank Jim Borbely of the Bureau of Labor Statistics for providing unpublished data on aerospace engineer demographics.

Within RAND, the authors gratefully acknowledge the help of RAND colleagues John Ausink and Mike Thirtle. Their prior research on the AIB greatly aided our work. We thank them both for providing their time, insights, and data. We would also like to thank our internal reviewers, John Birkler and Irv Blickstein, for their helpful comments and insights. They greatly help us clarify our message.

Abbreviations

ABIDES	Automated Budget Interactive Data Environment System
AFTOC	Air Force total ownership cost
AIB	aircraft industrial base
APUC	average procurement unit cost
DCMA	Defense Contract Management Agency
DoD	Department of Defense
FY	fiscal year
FYDP	Future Years Defense Program
LRSB	long-range strike bomber
MIBP	manufacturing and industrial base policy
MoD	Ministry of Defence
O&M	operation and maintenance
OSD	Office of the Secretary of Defense
OSD(AT&L)	Office of the Secretary of Defense (Acquisition, Technology and Logistics)
RDT&E	research, development, test, and evaluation
S&T	science and technology
SLEP	service life extension program
TOA	total obligation authority
UAS	unmanned aircraft system
USAF	United States Air Force

1. Introduction

The United States is facing a downturn in defense spending that it has not seen since the mid-1980s. Targets for these spending cutbacks are on the order of \$450 billion over the next decade, and there is a possibility of even more cutbacks, depending on the outcome of congressional budget negotiations.¹ Defense acquisition spending is not immune, and it is likely that a significant portion of these savings will come from defense procurement and research, development, test, and evaluation (RDT&E) spending. Thus, the ability of the United States to recapitalize its forces at the close of two wars will be significantly constrained.

During the last downturn in defense spending, the U.S. defense industrial base consolidated and shrank. Where there were once dozens of suppliers (e.g., within the aircraft industry), just a few now remain. In many areas, the industrial base is limited to sole-source suppliers. How the current spending downturn will affect the industrial base is of great concern to defense planners. How much further can the industry consolidate? Will the defense prime contractors and their lower-level suppliers remain financially viable? These two questions are key concerns facing defense planners.

This report brings together several separate threads of research in examining the implications for the aircraft industrial base (AIB) in light of the budget downturn the Air Force is facing. It is a collection of related research rather than a single line of analysis. The goal is to draw upon issues already identified and use them to answer key strategic questions as the Air Force considers how to manage the important, but inevitably shrinking, AIB.

At the heart of the issue is the current fiscal environment that the Air Force finds itself in:

- New aircraft procurement has been declining relative to other investments.
- Budgets are shrinking (and additional cuts are possible).
- Unit costs of aircraft are increasing exponentially.
- Equipment is aging.
- Modifications costs and cost per flying hour are increasing.

¹ See, for example, Clayola Brown, “Sequestration Cuts Would Destroy U.S. Economy, Congress Must Not Allow Devastating Cuts in Defense Spending,” *Baltimore Sun*, August 27, 2012; Joe Weisenthal, “GOLDMAN: Hide your Kids, the Sequester is Coming,” Business Insider website, January 15, 2013; and the Economist, “Squeezing the Pentagon: The Wrong Way to Cut America’s Military Budget,” July 6, 2013.

- There is still a need to maintain a technical edge and a viable and “competitive” AIB.

These conflicting pressures constrain the Air Force’s agenda in terms of force recapitalization that it would like to undertake in the next few years. Any recapitalization strategy must be considered within the context of the Air Force’s strategic vision for the next few decades.

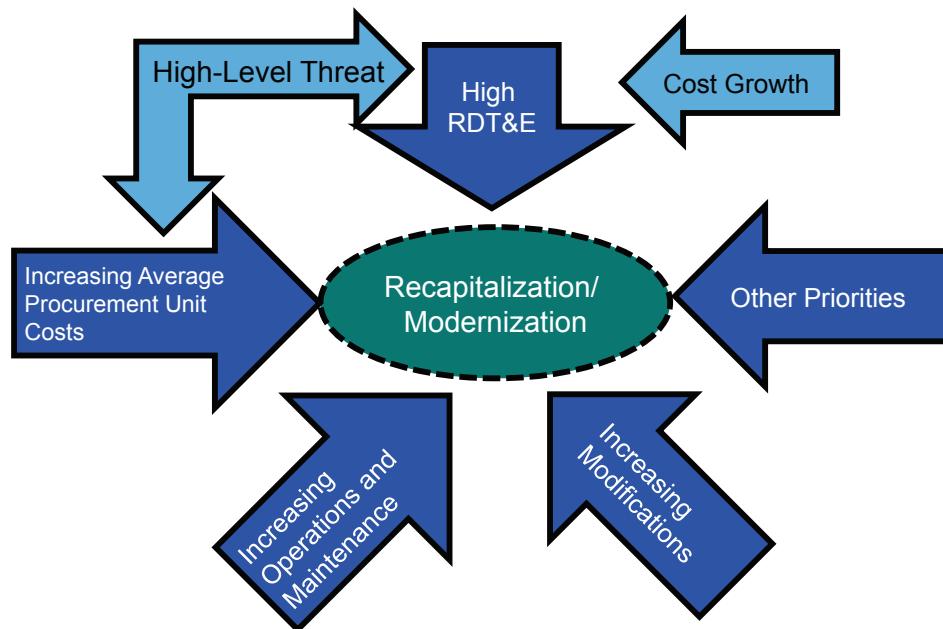
In considering these issues, we come to three basic questions:

- **How is the current situation different from the downturn in the mid-1980s?** In answering this question we examine historical budget and aircraft acquisition trends for the Air Force over the last several years. The material is largely drawn from public budget documents.
- **What can we learn from prior industrial base assessments to inform decisions for the future?** This question is addressed by a review of prior studies of the AIB—a meta-analysis of sorts. From this analysis, we attempt to draw common themes and lessons. We also assess the validity of some of the concerns by examining relevant data describing the industrial base.
- **What are the investment options for Air Force aircraft acquisition and how might they affect the industrial base?** This part of the analysis is a forward look at potential alternative courses of action the Air Force may pursue in terms of investment for the aircraft fleet. We hypothesize six different alternatives and examine the potential industrial base implications for each.

2. How Is the Current Situation Different From the Downturn in the Mid-1980s?

The first question leads us to examine budget patterns and trends to infer what might be likely in the current budget downturn, as shown in Figure 2.1.

Figure 2.1. Factors that Constrain Ability to Restructure/Modernize an Aircraft Fleet



There are a number of factors that constrain the ability of the Air Force to recapitalize its fleet. Figure 2.1 shows how these factors result in a decreasing ability of the Air Force to buy new aircraft. RDT&E spending is at an all-time high for aircraft (although some dispute this trend as will be discussed in the next section). This high funding level is driven by a number of factors:

- Advanced threats require more advanced, survivable and capable systems. To maintain this technical edge requires a significant amount of research and development.

- Weapons systems programs have traditionally had large cost growth over their initial estimates.¹ There are some indications that this has gotten worse recently. When there are technical problems and delays on programs (e.g., F-35), procurement funding is shifted into development funding thus delaying or reducing quantities. Hence, the ability to purchase new aircraft given a constrained budget is further restricted.
- Some believe that the higher RDT&E funding was part of a deliberate strategy to sustain the industrial base during the last downturn.²

Average procurement unit costs (APUCs) for aircraft have increased faster than inflation (roughly a 4 percent per year real growth; see Figure A.1 in the Appendix). Pugh and Augustine³ as well as others have observed high increases in the prices of weapons systems beyond typical measures of inflation. This growth in APUC is partially attributed to increasing complexity and sophistication of newer systems. Whatever the cause, the implication of such real growth is that fewer aircraft can be purchased over time as defense budgets seldom increase faster than the general economy for sustained periods.⁴

Newer, more capable fighter and bomber aircraft are more expensive to maintain and operate than older ones. This increasingly expensive operation and maintenance (O&M) for the aircraft fleet is another factor that constrains the Air Force's ability to modernize (i.e., more funds must be devoted to O&M as opposed to procurement). Figure A.2 in the appendix shows that recent tactical aircraft are two to three times more expensive per flying hour than older generations.

The Air Force has also shifted its funding priorities over time (shown as the “increasing modifications” and “other priorities” arrows in Figure 2.1). In the next few figures we show that overall procurement has declined, and of that smaller procurement, more is being spent on non-aircraft procurement, and more of the aircraft procurement is being spent on aircraft modifications than new aircraft. These shifts suggest that the situation today is very different than the previous downturn.

¹ See, for example, Obaid Younossi, Mark V. Arena, Robert S. Leonard, Charles Robert Roll, Arvind K. Jain, and Jerry M. Sollinger, *Is Weapon System Cost Growth Increasing? A Quantitative Assessment of Completed and Ongoing Programs*, Santa Monica, Calif.: RAND Corporation, MG-588-AF, 2007.

² The record on this as a deliberate strategy isn't clear. See, for example, the discussion on The Technology Reinvestment Project in John Accordino, *Captives of the Cold War Economy: Struggle for Defense Conversion in American Communities*, Westport, Conn.: Praeger Publishers, 2000, p. 9.

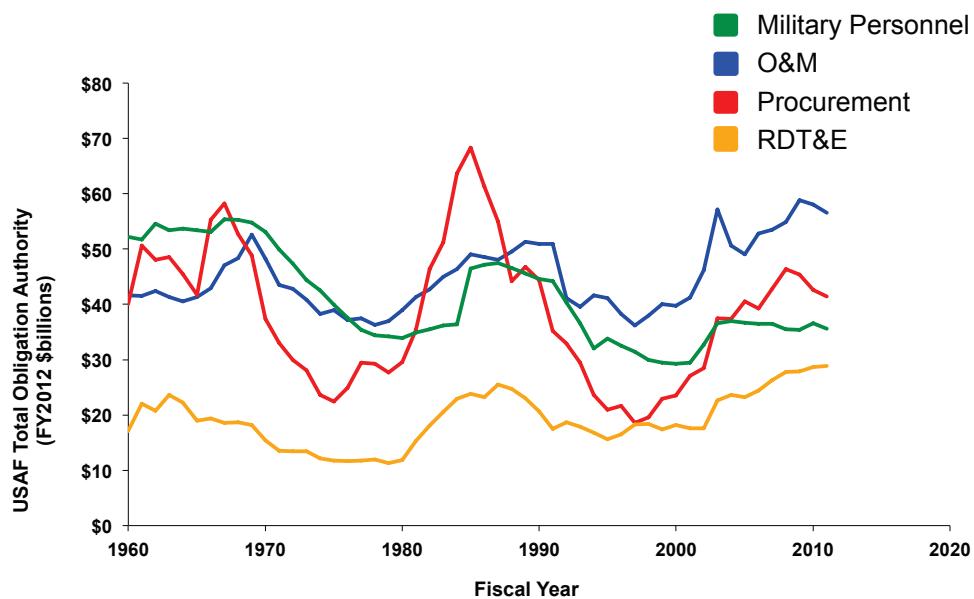
³ Philip Pugh, *The Cost of Seapower: The Influence of Money on Naval Affairs from 1815 to Present Day*, London: Conway Marine Press, 1986; Norman R. Augustine, *Augustine's Laws*, 6th ed., New York: Viking Penguin, 1997.

⁴ A recent exception to this is the growth experienced during Operation Iraqi Freedom and Operation Enduring Freedom period.

In Figure 2.2 we've plotted the Air Force's Total Obligation Authority (TOA) for four funding categories: procurement; RDT&E; O&M; and military personnel. These data represent total Air Force budget authority (both blue and non-blue). Recent years include the enacted supplemental funding.

There has been a cyclical nature to the budget authority with brief peaks every 15 to 20 years. This cyclical pattern is most pronounced for the procurement account. Over the longer term, some interesting patterns are apparent in the accounts. In the 1960s, military personnel and procurement were generally the two largest items of the four. The military personnel account has declined with time. In the current decade, military personnel is the third largest account. The O&M account is at an all-time high, only partially driven by ongoing operations. Moreover, RDT&E spending is also at an all-time high and trending upward. Procurement, as stated before, has been highly cyclical but over the five decades it has trended downward. More important, the "peak" around 2009 (about doubling since the late 1990s) is far lower than that seen during prior peaks in the mid-1980s and late 1960s. It appears as if the cyclical recapitalization opportunity has been greatly diminished this time (or perhaps missed completely).

Figure 2.2. O&M Dominates Air Force's Total Obligation Authority



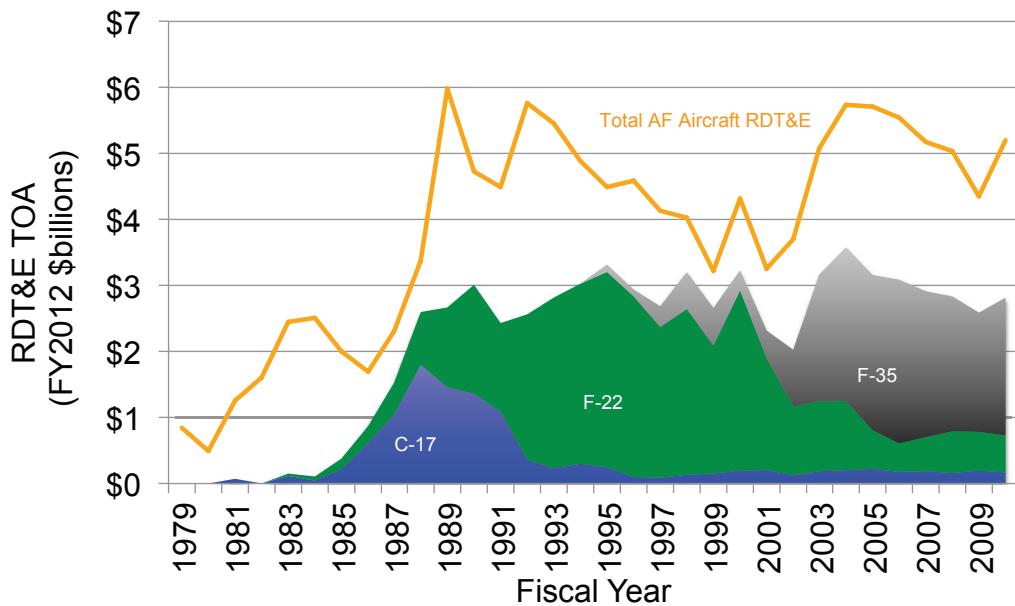
Source: Office of the Under Secretary of Defense (Comptroller), *National Defense Budget Estimates for FY 2012*, March 2011.

Note: Non-blue spending represents funding that the Air Force receives as a "pass-through" (not managed by the Air Force) to other organizations. The non-blue funding largely supports the National Intelligence Program, Defense Health Program, and Special Operations Forces.

Figure 2.3 shows the Air Force aircraft portion of RDT&E (TOA) over the period 1979 through 2010. RDT&E spending on aircraft has been strong and relatively stable since the increase in the late 1980s. Three programs dominate the RDT&E spending: F-35, F-22, and C-17. These data come from the Air Force Automated Budget Interactive Data Environment System (ABIDES).

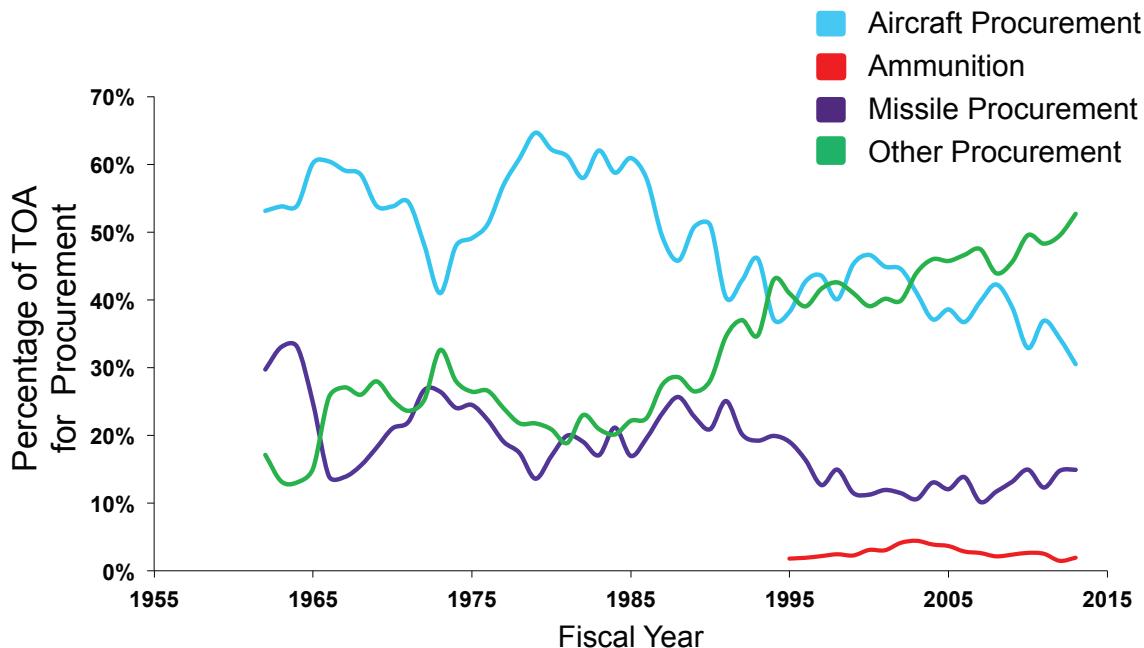
Shifting from RDT&E, Figure 2.4 shows procurement for aircraft, missile (which includes space and other related support), ammunition, and “other” (i.e., non-blue, cyber, electronics and telecom equipment, vehicles, etc.) accounts as a percentage of the overall Air Force procurement TOA. There has been a long-term funding shift out of aircraft procurement (dominant up to the mid-1990s)—most notably into the “other” accounts.

Figure 2.3. Air Force Aircraft RTD&E Rates



Source: ABIDES Data

**Figure 2.4. Air Force Aircraft Procurement Budget Authority
Relative to Other Procurement**

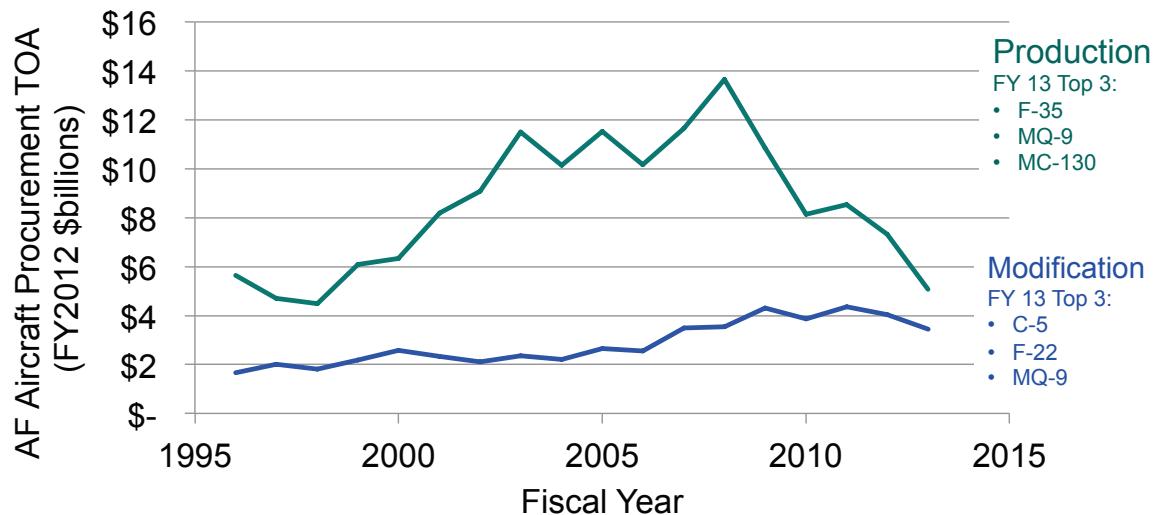


Source: U.S. Air Force

If we examine the aircraft procurement TOA in more detail, another important trend emerges – the procurement funds spent on modifications to existing aircraft have increased steadily over the past decade. Figure 2.5 shows how the Air Force’s procurement TOA (in constant fiscal year [FY] 2012 dollars) is split between modifications and production. As examples, the top three programs for each category in FY 2013 are listed beside the lines. These data are drawn from ABIDES. This increasing trend for modifications implies that fewer procurement funds are available to purchase new aircraft—thus hindering the ability of the Air Force to recapitalize the fleet at a greater rate.

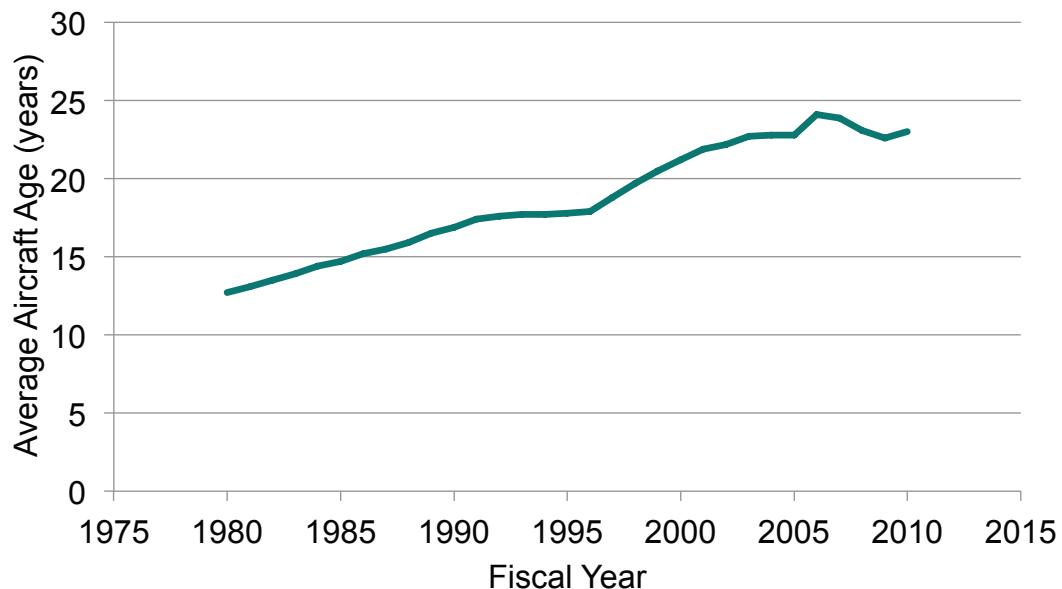
Another significant difference between the current downturn and the prior one experienced in the 1980s is that the current fleet is much older. Figure 2.6 shows that the average age for an aircraft (active inventory) has increased over 50 percent since the last downturn. The increase in modification funding (shown in Figure 2.5) is partially a symptom of this older fleet, but the question is how long modifications will keep the current fleet viable. The previous downturn followed significant new aircraft procurement in terms of numbers, and therefore the Air Force had a relatively new fleet to rely on during this period. This time, however, the downturn is taking place with a much older fleet.

Figure 2.5. Within Air Force Procurement, Modification Funding Is Increasing While Production Is Decreasing



Source: ABIDES

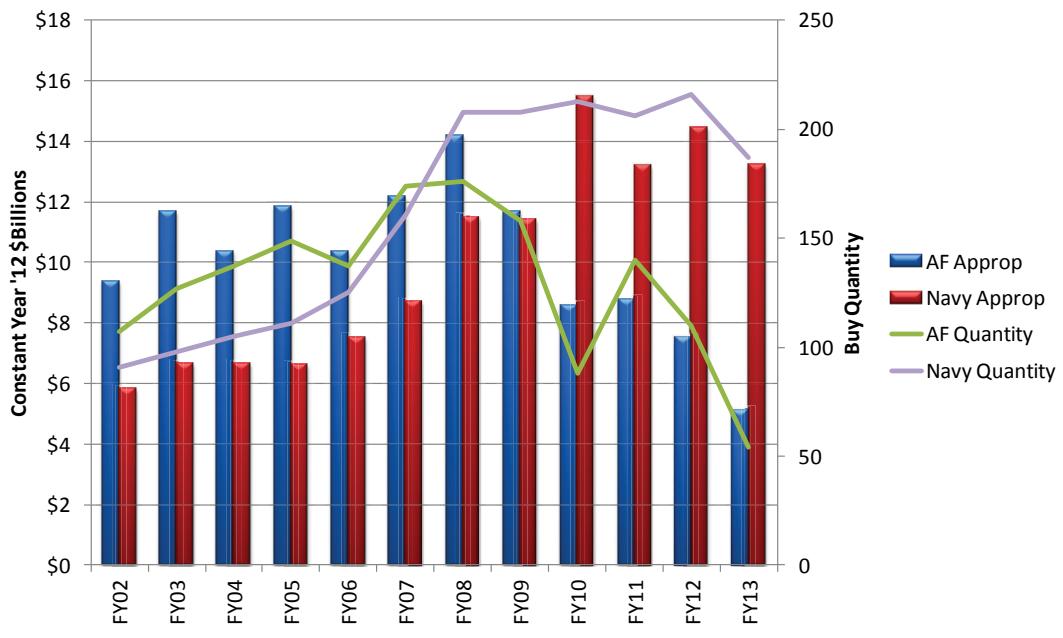
Figure 2.6. Fleet Age Has Increased by More Than 50 Percent Since Last Downturn



Source: Deputy Assistant Secretary (Cost and Economics), Assistant Secretary of the Air Force (Financial Management and Comptroller of the Air Force) SAF/FMC, *United States Air Force Statistical Digest, Fiscal Year 2010*, 2010.

Figure 2.7 illustrates the differences in quantities and dollars for new aircraft procurement between the Air Force and Navy. From FY 2002 through FY 2007, the Air Force dominated the procurement in both numbers and dollars. Since FY 2010, the ordering has reversed, where the Navy now has the greater spending and higher quantities. FY 2013 represents a spending low (both in terms of dollars and numbers) for new Air Force aircraft procurement over the past decade. Figure 2.7 does not imply anything in terms of the capabilities being acquired—it is meant to illustrate trends in procurement: The Air Force has trended downward whereas the Navy has trended upward. The important message from Figure 2.7 is that the Navy now dominates the production industrial base. So their decisions could substantially affect the Air Force's ability to procure new aircraft in the future.

Figure 2.7. New Aircraft Procurement: Air Force vs. Navy



Source: U.S. Air Force

Changes in Strategic Environment Complicating Recapitalization/Modernization

There are a number of other important trends since the last budget downturn that further complicate the Air Force's current budget environment. One of the more significant changes is the greater demand for and use of remotely piloted systems (also known as unmanned aircraft systems or UAS). Such systems are increasingly important in the current war against terrorism and ongoing operations. Their capabilities aren't necessarily

a replacement of existing manned systems, but often an additional capability based on operational demands. While highly effective and useful, these systems also pose a competing demand for Air Force procurement dollars. However, a positive effect of this new market is that new firms have entered the defense aircraft sector (as will be discussed in a subsequent section).

Another trend that has emerged since the last downturn is the increasing demand on information gathering and dissemination/sharing. These new capabilities make any one aircraft system more effective, but raise complexity and price.

Today's strategic environment differs greatly from that of the last downturn, which was the result of the Cold War ending with no obvious near peer threats or competitors to U.S. military power. Today, the United States is winding down two ongoing operations that have placed a significant demand on personnel and equipment. While these are ending, the hunt for terrorists (more broadly asymmetric warfare) continues, and the Air Force remains engaged in steady-state operations around the world.

But perhaps the most important difference is the emergence of a highly capable competitor in the Pacific region. This competitor is growing its military capability both in size and sophistication, with aims to deny access and counter U.S. capabilities. Further, this growth (up to now) has been fueled by a very strong economy.

The Air Force must balance between conflicting demands of preserving near-term capabilities and investing in the future capabilities. Whatever path the Air Force takes, its choices will shape the AIB. Understanding these implications is important to inform these decisions. In the next chapter, we explore the health of the industrial base and the lessons from prior studies of it.

3. What Can We Learn from Prior Industrial Base Assessments to Inform Decisions for the Future?

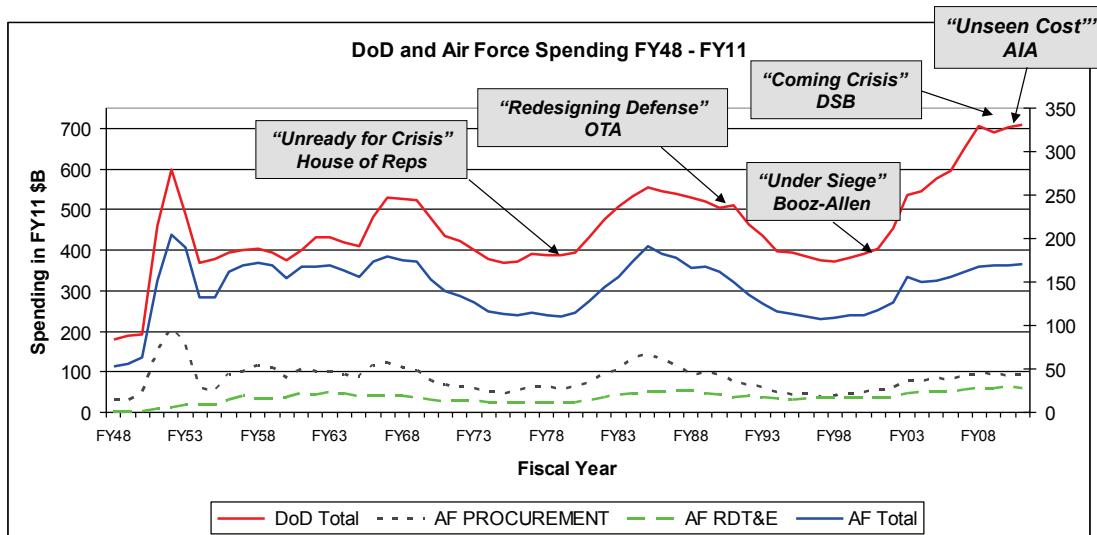
The AIB is a vital capability that the Air Force relies upon to develop, produce, and support its aircraft fleet; thus, its health is of strategic importance. Without these capabilities, the Air Force may not be able to field the systems it needs to meet future requirements. In this section, we summarize information and lessons from prior studies of the AIB to help inform the Air Force’s budget decisions. Many of these studies have explored the AIB’s health (or lack thereof). We’ll examine the concerns about the AIB raised by these evaluations and try to set some of these concerns within the context of objective data.

In related research, RAND researchers performed a meta-analysis of hundreds of studies of the U.S. AIB.¹ While there are many interesting findings of this work, perhaps the most interesting one is the relationship between the projected health of the industrial base and the budget context. Figure 3.1 shows a sampling of some of the titles for major studies of the AIB that forecast serious AIB problems.² These titles are overlaid on the overall Department of Defense (DoD) and Air Force budget cycles.

¹ John Ausink and Michael Thirtle, unpublished RAND research, 2011.

² See Aerospace Industries Association, *The Unseen Cost: Industrial Base Consequences of Defense Strategy Choices*, 2009; Defense Science Board, *Creating an Effective National Security Industrial Base for the 21st Century: An Action Plan to Address the Coming Crisis, Report of the Defense Science Board Task Force on Defense Industrial Structure for Transformation*, Office of the Assistant Secretary of Defense for Acquisition, Technology, and Logistics, Washington, D.C., July 2008; John R. Harbison, Gen. Thomas S. Moorman, Jr. (USAF retired), Michael W. Jones, and Jikun Kim, *U.S. Defense Industry Under Siege: An Agenda for Change*, Booz-Allen Hamilton, 2000; Office of Technology Assessment, *Redesigning Defense: Planning the Transition to the Future U.S. Defense Industrial Base*, OTA-ISC-500, July 1991; and US House of Representatives, 1980.

Figure 3.1. Alarmist Studies Appear in Both Up and Down Budget Cycles



Source: John Ausink and Michael Thirltle, unpublished RAND research, 2011.

Note: DoD spending is read from left axis; AF spending is read from right axis.
Spending includes Overseas Contingency Operations (OCO).

One might expect more concerns to be raised during downturns rather than upturns. However, the portents of future calamity in the AIB seem to have little relationship to the budget itself. It is not clear why this might occur. The RAND work speculates as to several possible reasons including:

- Lack of objectivity—the original studies’ authors may have certain agendas or interests in mind, such as an industry group advocating for their members.
- Lack of a rigorous methodology to assess the health of the AIB—there are no universally accepted measures of health. Cash flow, number of programs, and workforce numbers are examples of metrics used. However, none seem adequate in completely describing the state of the AIB, nor are they used consistently in the studies.
- Difficulty in forecasting budgets and military needs just a few years ahead.
- Garnering more attention—the more sensational the findings, the more likely it is to attract the attention of the public, media, and the Congress.

The RAND meta-analysis also revealed:

- Primes have evolved from a vertically integrated approach (design and manufacturing of most components) to one where they now focus on design, integration and final assembly activities. Extensive supplier sub-tiers do much of the component design and manufacturing work.
- Linked to the outsourcing trend above, the AIB is now drawing upon vendors worldwide, not just from the United States. In some cases, certain classes of materials and components (such as titanium sponge, rare-earth metals, and

integrated circuit chips) are almost exclusively purchased from foreign sources. Moreover, major assemblies are being produced overseas, such as the aft portions of the F-35. While this outsourcing has kept the primes more competitive, it creates vulnerability in terms of stable sources of supply and security.

- The source of innovation is no longer the sole domain of the primes. Innovation now comes from both the primes and their suppliers.
- As acquisition of complex systems becomes more expensive (in both design and production), there is a trend towards procuring systems that satisfy joint (multiservice) or combined (international) requirements. The Joint Primary Aircraft Training System, F-35, and Eurofighter are examples of this recent trend.

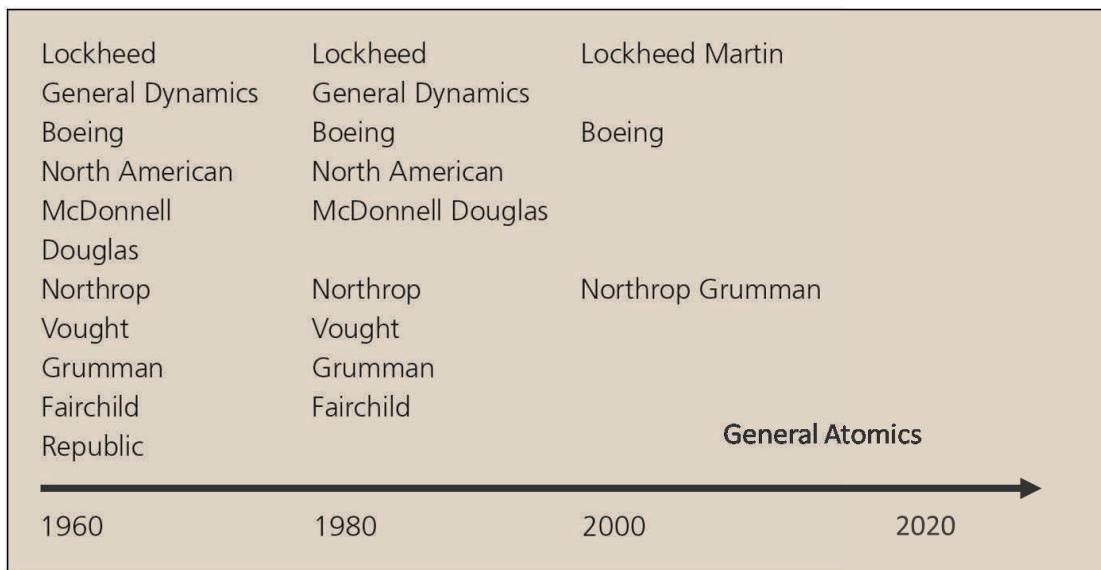
Finally, the meta-analysis results identified some specific concerns about the AIB and possible consequences. Some of these concerns are

- reduced competition due to consolidation
- loss of skilled personnel due to consolidation
- questions on whether certain sectors of the industry would remain financially viable.

These concerns could have a number of undesirable consequences. Due to consolidation and lack of experienced workers, for example, the aircraft industry may not be able to meet the Air Force's demand for technologically advanced systems in a timely way. As industry shrinks and loses key skills, there is a concern that the pace of innovation will slow down or cease. Finally, the lack of competition might lead to prices for systems that are unaffordable. In sole source situations, contractors will not have as much incentive to control costs.

Most studies concluded that while the current AIB is healthy, problems are looming. Figures 3.2–3.4 address these concerns.

Figure 3.2. AIB Has Contracted Considerably at the Prime Level



Source: John L. Birkler, Paul J. Bracken, Gordon T. Lee, Mark A. Lorell, Soumen Saha, and Shane Tierney, *Keeping a Competitive U.S. Military Aircraft Industry Aloft: Findings from an Analysis of the Industrial Base*, Santa Monica, Calif.: RAND Corporation, MG-133-OSD, 2011.

Figure 3.2 shows how the number of aircraft prime contractors has diminished every 20 years. Of the 11 prime contractors in the 1960s, only three remain today. This is a reflection of the overall contraction of defense spending and the related fact that the number of new program starts has decreased and continues to do so. F-15 and F-22 production has ended and it is anticipated that F-18 and F-16 production will end in the next few years. F-35 will be the only manned fighter program for some time. The long-range strike bomber (LRSB) and the KC-46A tanker might be the only new fixed-wing programs in production in the next couple of decades. It isn't clear there is enough work and new programs to keep the three traditional primes viable in the fixed-wing segment.

The UAS market and demand, on the other hand, continues to grow. In fact, a new supplier, General Atomics, is now considered a prime for this particular market segment of the AIB. It is anticipated that the UAS market will continue to be strong. But such demand may not be able to substitute for work on fixed-wing manned aircraft.

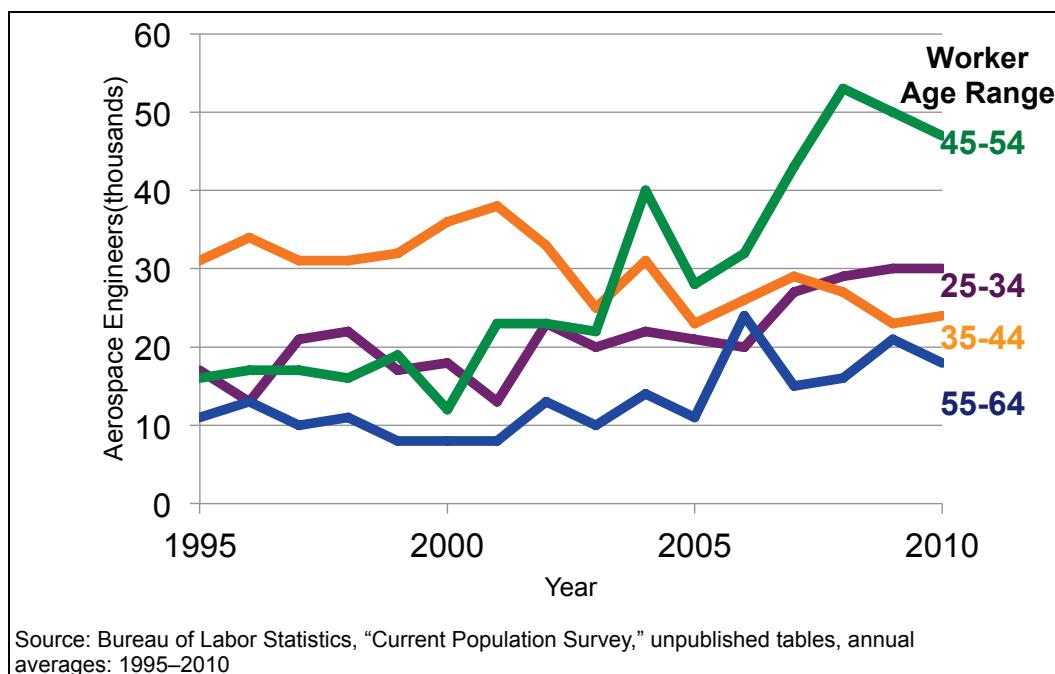
One of the major concerns expressed by industry is an aging workforce. Such a shift in demographics could cause shortfalls of trained and experienced workers needed for new programs. Figure 3.3 shows the shift in age demographics for aerospace engineers in the United States.³ We selected this engineering discipline as it is believed to be one of the more challenging workforces for the AIB to grow and maintain. These data come

³ Please note that these data cover all U.S. industry and not just those supporting DoD.

from unpublished tables from the Current Population Survey conducted by the Bureau of Labor Statistics from 1995 to 2010. Two distinct trends are evident from the data. First, the overall aerospace engineering workforce increased from roughly 79,000 to 129,000 workers since 1995. The other trend is that most of this growth has occurred in the 45- to 54-year-old population. The 35- to 44-year-old population slightly declined whereas the other age groups (the extremes of the population) have increased.

There are both good and bad implications from these trends. There appears to be no decline in the number of aerospace engineers and it seems possible to substantially grow this workforce in a few years. This workforce segment has grown by more than 60 percent in 15 years. However, the AIB might have trouble retaining mid-career workers as evidenced by the decline in the 35- to 44-year-old population. Also, most of the growth of this workforce has been in the age range that will retire in the next ten to 20 years. So when the next new fixed-wing program starts (e.g., next-generation fighter — currently beyond the Future Years Defense Program [FYDP]), many of these experienced workers will be eligible for retirement.

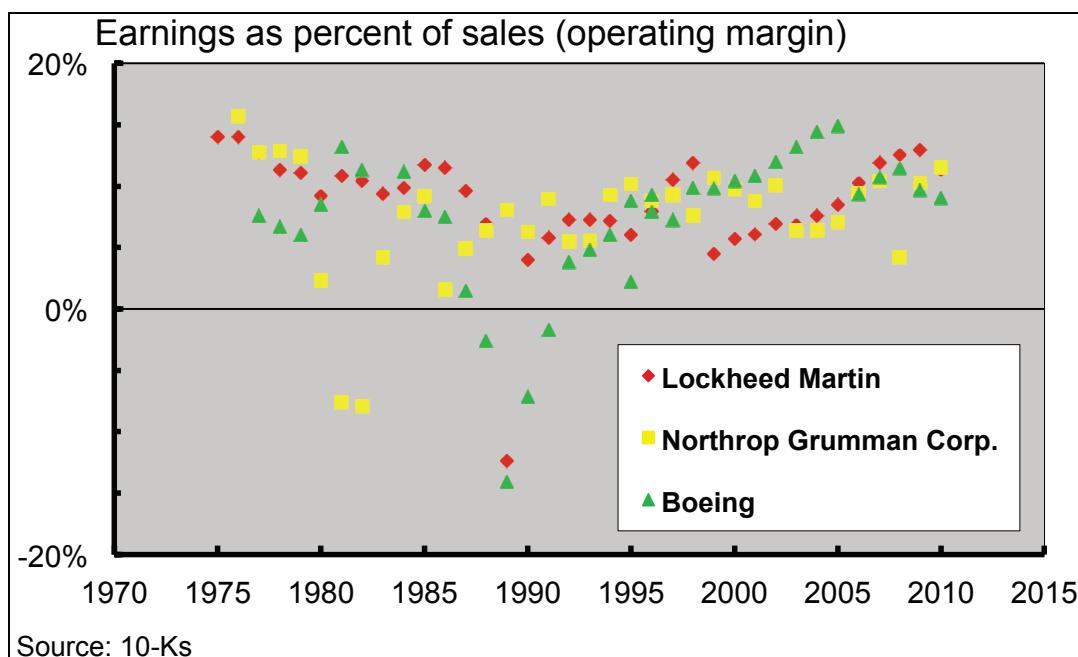
Figure 3.3. Workforce Aging Issues Are Mixed



Of the three major AIB concerns, financial viability is one of the harder ones to examine. In Figure 3.4, we explore this issue through a measure of profitability. To assess changes in profitability with time, we examine the annual reports (10-Ks) for the three primes and extracted data on their operating margin in their defense aircraft/aerospace sector.⁴ These reports are publicly available on the Securities and Exchange Commission's website.⁵

Most notably, there have only been a few years since the 1970s where the firms have not had positive operating margins. The drop in profitability by Lockheed Martin in 1989 is directly attributed to the last downturn and the restructuring that resulted. For Boeing, the dip in operating margin (also in the late 1980s) is attributed to restructuring due to the downturn and poor profitability on some cost sharing contracts. Northrop Grumman Corp. did not provide much detail on the dip in the early 1980s. So two of the three primes' profitability was directly influenced by the previous downturn. However, these firms have remained quite profitable over the 35 years for which we have data.

Figure 3.4. Despite Some Dips, Corporate Aerospace Margins Have Not Suffered



⁴ Operating margin is the ratio of earnings relative to total sales.

⁵ U.S. Securities and Exchange Commission, Filings and Forms web page, modified February 21, 2012.

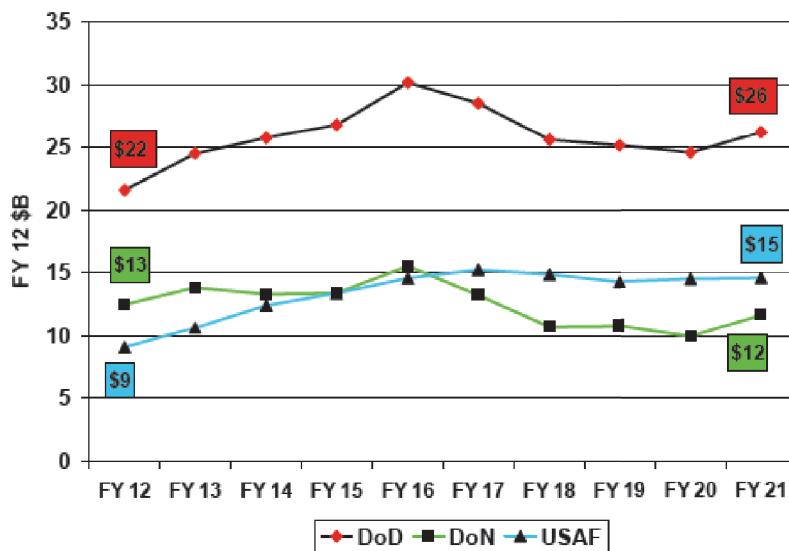
Each year as part of the budget, DoD submits its long-term plan with respect to aircraft procurement. This congressionally mandated plan looks out 30 years across the Air Force, Navy, and Marines, and projects programs, purchases, and fleet inventories. The plan serves as a basis for future DoD planning and can inform the future business base for industry. At the time of this research, the most recent of these reports, *Aircraft Procurement Plan, Fiscal Years 2012–2041, Submitted with the FY 2012 Budget*, was published in March 2011, based on funding profiles before many of the current budget reductions were defined.⁶ Nonetheless, this report provides insight into capabilities that are going to be emphasized. The major objectives identified, in terms of purchases of new and existing aircraft, include:

- “Meet the demand for persistent, unmanned, multirole intelligence, surveillance, and reconnaissance capabilities.” These objectives will mainly be met through UAS systems, whose inventories are projected to nearly double in the next 10 years.
- “Provide sufficient enabler capability and capacity.” These objectives will be met, in the near term, through the replacement tanker program and replacing of the Navy’s E-2, F-18G and P-8 fleets.
- “Acquire fifth-generation fighter/attack aircraft while maintaining sufficient inventory capacity.” This objective will be primarily met through the F-35 program and some purchases of new F-18s.
- “Modernize long-range strike capabilities.” This objective will be largely be driven by the Air Force’s LRSB program.

Figure 3.5 illustrates that the spending required to support these objectives is rather steady, mostly between \$25 billion and \$30 billion in constant FY 2012 dollars. So there does not seem to be a decline in overall spending planned (as of March 2011).

⁶ Office of the Secretary of Defense, *Aircraft Procurement Plan, Fiscal Years (FY) 2012-2041, Submitted with the FY 2012 Budget*, March 2011.

Figure 3.5. Projections of Aircraft Investments Steady



Source: Aircraft Procurement Plan 2012-2041

Note: Plan does not include trainers, OSA/VIP, and helicopters, etc.

However, there are notably few new program starts both within the FYDP and beyond it. The list within the FYDP includes

- UCLASS
- USMC Group 4 UAS
- KC-46A
- LRSB
- AR/LSB (C2 replacement)
- Follow-on UAS.

The list beyond FYDP includes

- F-X
- Strategic lift replacement
- NGAD.⁷

Within the FYDP, there are potentially three new UAS programs, the tanker replacement program, and the LRSB.

Why are new programs so important? New programs use the technical workforce very differently than existing programs. In order to sustain key technical and manufacturing start-up skills, new programs must come along at regular intervals or these skills atrophy. In the short term, the LRSB will be a key program in sustaining technical

⁷ We have not been comprehensive in naming all programs but merely list the major ones to illustrate the examples. F-X is not in the long-range plan (beyond FY 2021), but it is in internal Air Force documents.

skills in the AIB. Beyond the FYDP, there are potential plans for new fighter/strike aircraft as well as a potential strategic lift replacement program. But these new programs could be well over a decade away from today.

Recent AIB Studies Offer Conflicting Messages

With the backdrop of the long-range plan described in Figure 3.5, there are three recent studies of the AIB that come to different conclusions on its health.

1) Birkler et al., 2011.⁸ This RAND study, requested by Congress, examines the long-term competitiveness of the AIB. The authors define a competitive industrial base as being one where there are at least two primes with approximately equal shares of RDT&E and procurement funds. In the view of the authors, the situation is relatively stable today—given current RDT&E levels at historic highs. They also observe that adding the LRSB program would help to sustain a competitive industry through 2020. A next-generation fighter program start would be needed by around 2016 and would sustain a competitive industry through 2025. Note that this start for the F-X program is far earlier than currently planned by the Air Force.

2) Office of the Secretary of Defense (Acquisition, Technology and Logistics) (OSD[AT&L]) Manufacturing and Industrial Base Policy (MIBP), 2011.⁹ This study was less sanguine about the industry’s health (although it should be noted that the authors took a more expansive view beyond the fixed-wing sector). According to the authors, “Military aircraft design and development workload is at a historic low and RDT&E funding is expected to continue to decrease.”¹⁰ Further, this lack of spending would lead to atrophy and the potential for loss of key design and development capabilities. The fact that the workforce was seen to be aging exacerbates the situation. On the other hand, they view procurement funding to be strong—and in particular the UAS market is seen to be large and robust. They project increasing global partnerships from European suppliers due to lack of international demand.

3) Defense Contract Management Agency (DCMA) Industrial Analysis Center, 2011.¹¹ A recent study by DCMA also sees challenges for the AIB. DCMA concluded

⁸ Birkler, Bracken, Lee, Lorell, Saha, and Tierney, 2011.

⁹ OSD(AT&L), *Manufacturing and Industrial Base Policy (MIBP)*, Annual Industrial Capabilities Report to Congress, Washington, D.C., September 2011.

¹⁰ While this might seem contradictory to our earlier conclusions on RDT&E spending, MIBP may have considered the AIB beyond the fixed-wing sector (e.g., rotary wing and engines) and come to differing conclusions. It is unclear from their report which services and industry subelements they evaluated.

¹¹ Defense Contract Management Agency Industrial Analysis Center, *Aircraft Sector Industry Assessment*, November 2011.

that the current programs of record will marginally sustain the AIB, but budget cuts could significantly degrade capability. Modification activities alone will not be enough to sustain the industrial base or preserve fleet readiness. New procurement programs are needed. The F-35 program dominates the fighter IB future and potentially skews the industry to one dominant prime. Global access to strategic materials will continue to be a challenging issue. By 2015, legacy fighter programs will likely end production. At this point, the industrial base will begin to atrophy in terms of production capabilities. There will be limited domestic industrial options for future competition and teaming arrangements. A new procurement holiday will likely accelerate industry restructuring. Pratt and Whitney will be challenged to grow its commercial market in an effort to be more cost competitive; Northrop Grumman Corp. aircraft segment is seen as vulnerable during a downturn; Boeing's capabilities are uncertain without additional research and development funding. However, UAS demand will remain strong.

While the three studies come to differing conclusions in terms of the health and concerns with respect to the AIB, three important themes emerge:

- the importance of the LRSB program starting soon in preserving technical skills in the AIB
- the F-35 will dominate and shape the AIB for the coming decade
- uncertainty on whether Northrop Grumman Corp. will remain a viable prime for manned aircraft.

Military Aircraft Design and Development Requires Skills Not Found in Commercial Sector

An important consideration in thinking through the challenges facing industry during a downturn is the preservation of key skills. While there are a vast array of skills that go into developing and building both commercial and military aircraft, there are some that are unique to the military sector.¹² These skills tend to concentrate in areas that are critical to mission performance:

- combat maneuver and propulsion
 - transonic/supersonic/hypersonic
 - high angle of attack
 - Short Takeoff and Landing/Short Takeoff and Vertical Landing
 - high-g structures
 - carrier operations

¹² David S. Cadman, "Aircraft Sector Industrial Overview," briefing, Defense Manufacturing Conference, December 3, 2009.

- thrust vectoring
 - high altitude
- human interface
- weapon system integration
 - target acquisition
 - stores management
 - weapons separation
- survivability
 - low observable
 - Electronic Warfare/Electronic Counter Measures
 - egress systems
 - radiation hardening
 - ballistic tolerant structures
 - fire detection and suppression
- sensors.

There are other skills, while used to some extent in the commercial industry, which are used at a much higher level of complexity for military aircraft:

- program management
- avionics
- human interface
- systems integration.

As the Air Force thinks through strategies in preserving key skills for future programs, it is these unique skills that deserve the most attention.

Lessons from the Experience with the United Kingdom's Spending Downturn

The United States has never faced a situation where it was unable to produce a major weapon system due to an inability of the industrial base to execute. Programs might take longer or cost more than initially planned—but the United States has always been able to develop and produce a required capability. However, there are examples from other countries where there were substantial problems in rebuilding a capability/capacity. Such examples can offer valuable lessons for the Air Force in the current budget downturn.

The United Kingdom's *Astute* program is a recent example of a complex weapon system that ran into development and production problems due to a gap in development

and production activity that was a result of a downturn in funding.¹³ Similar to the United States, the United Kingdom faced a spending downturn at the end of the Cold War in the late 1980s. The spending decline resulted in a major restructuring within both the government and industry.

For the sole-source submarine manufacturer, this decline resulted in large layoffs and losses of experienced workers. There was a gap of nearly a decade between the last delivery of the previous class of submarines and the first boat of the new *Astute* class. The submarine design and manufacturing facility remained open by pursuing surface ship work (and trying to enter into some commercial programs—unsuccessfully).

Similarly, the Ministry of Defence (MoD) faced personnel reductions of its own due to cost-savings initiatives. Many of its technical and program management staff in the submarine community were lost. Moreover, the MoD pursued a new strategy where most of the responsibility for weapon system acquisition was delegated to industry, following a more commercial approach (similar to the U.S. Total System Performance Responsibility approach). The gap and loss of expertise resulted in the *Astute* program having numerous technical, schedule, operational, and cost problems that still persist today. These challenges were so significant that the United Kingdom had to use U.S. industry to help them get the program moving forward.

There are some broader lessons for the Air Force to consider from the *Astute* experience:

- The Air Force should preserve technical and management capabilities and should not assume that industry will maintain capabilities during a gap. Furthermore, commercial work and FMS may not be sufficient sources of work to sustain military design and production skills.
- Domain experience matters. When submarine work restarted in the United Kingdom, engineers from the prime's aerospace division initially supported the program. While technically competent, these engineers lacked the specific domain knowledge needed to effectively design a safe and reliable system. In addition, during the competition portion of the development, the MoD opened the bidding to producers who had little experience in submarine design and manufacture. This approach resulted in prices that were unrealistically low. Further, while the United States was able to step in and help the United Kingdom, there is no fallback partner for the United States if capabilities languish.
- The Air Force should resist cutting skills that are needed to oversee programs to achieve near term budget savings. The MoD lost much of its own ability to technically oversee the program and was not able to recognize problems until very

¹³ John F. Schank, F. W. LaCroix, Robert E. Murphy, Cesee Ip, Mark V. Arena, and Gordon T. Lee, *Learning From Experience, Vol. III: Lessons from the Submarine Programs of the United Kingdom's Astute Submarine Program*, Santa Monica, Calif.: RAND Corporation, MG-1128/3-NAVY, 2011.

late. Force structure plans should be aligned with the overall budget outlook, and should not rely on international sales to mitigate shortfalls in domestic demands. The UK's naval ship program (or at least the plan for it) was much greater than the budget could sustain. So, industry was unable to size itself rationally as leaders believed better times were "just around the corner." This unrealistic plan, in part, led to a great deal of churn in ownership of the firms rather than a much-needed consolidation that happened later.

In the next chapter, we examine alternative investment options and how they may help the Air Force address these challenges.

4. What Are the Investment Options for Aircraft Acquisition? How Might They Affect the Industrial Base?

In this chapter, we explore a range of potential investment options open to the Air Force and consider their implications for the industrial base. The review of these options is not meant to be a detailed budget exploration of programs and quantities, but rather a discussion of potential funding strategies and their pros and cons. We only explore options within the aircraft funding accounts. We do not explore the larger funding trades open to the Air Force (such as spending more on aircraft procurement while reducing procurement in satellites, or changes to force levels and personnel to reduce operations and support spending). These larger trades were viewed to be beyond the scope of this report.¹

The Air Force Must Balance Current Capability and Future Capability

As we stated in the beginning of this report, balancing the budget during a downturn means that the Air Force must make difficult choices between competing demands for funds. These choices must balance the need for current capabilities versus future capabilities. And this balance means different levels of spending between the main budget accounts. In terms of sustainment—O&M funding, procurement modifications, and service-life extension programs (SLEPs)—the Air Force maintains current systems until these aircraft are replaced when the budget environment allows. However, maintaining older systems can become increasingly expensive and siphons money from RDT&E and procurement.

For procurement, the Air Force builds inventories and introduces some new capabilities. However, newer aircraft with improved capabilities are typically more expensive to buy and sustain than older ones. This trend makes it difficult to maintain force levels unless budgets are increasing at the same rate.

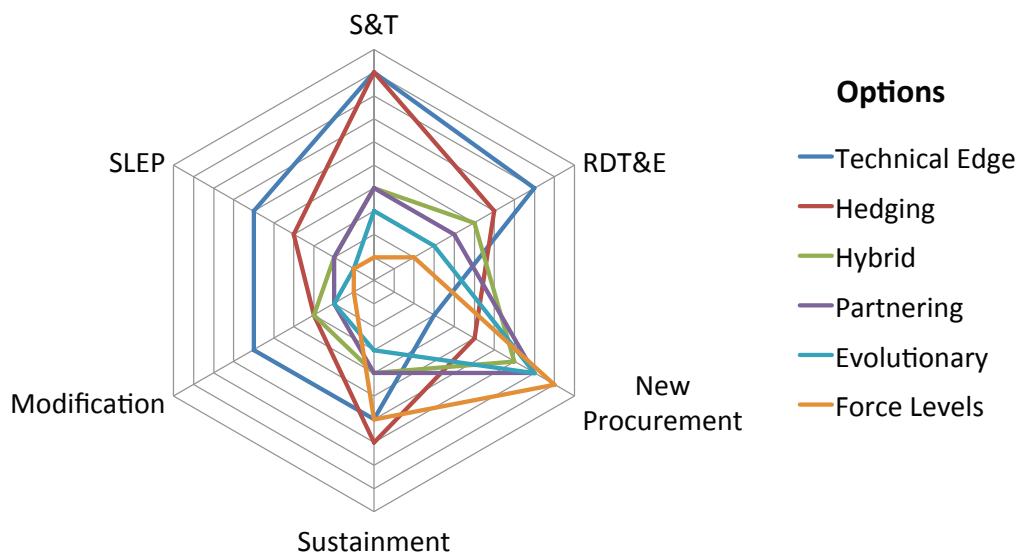
A focus on recapitalization/modernization might squeeze RDT&E and sacrifice the capability of future systems. A focus on RDT&E enhances future capability, but in the short term displaces recapitalization/modernization funding and could cause shortfalls in near-term inventories. Whatever balance the Air Force chooses to make between near- and long-term capabilities, this choice has significant implications for the industrial base.

¹ For a discussion of the broader force structure trades, see Michael Donley, “How Low Can The Air Force Go?” AOL Defense, January 9, 2013.

Once a choice is made, the Air Force can then go on to understand the effects on the AIB and how problems may be mitigated.

In exploring the funding strategies open to the Air Force, we develop six investment options and plot them in terms of how relative spending would appear among the budget categories (See Figure 4.1).² These options do not represent all possibilities (in fact, a few might be combined).

Figure 4.1. Future Strategic Funding Options for Air Force Aircraft in a Declining TOA



The six options are meant to cover a wide range of the decision space to help inform the Air Force on the implications of each. None represent a total commitment to one direction, but rather a specific focus on one area over the others. For example, an option to focus on new procurement would not eliminate funding in other areas. There are six options:

- **Maintain a Technical Edge.** This option would develop new systems to counter high-end threats. It emphasizes RDT&E spending and stretches out procurement while minimizing sustainment and modernization. New systems are bought as they are developed but at a slow pace. Some SLEP funding may be needed to support fleet inventory levels in the short term.
- **Hedging Strategy.** This strategy would develop new technologies through prototyping, but delay converting them into new operational systems until needed. The focus is to keep pace with an evolving, highly technical threat and anticipate

² Science and technology (S&T) is spending on early, basic, science and technology development and not geared toward a specific system.

a budget upswing in the future. However, it also assumes that there would be enough advanced notice to start and ramp production up to meet a threat when it materializes.

- **Hybrid Strategy.** This mixed option leverages the commercial and military industrial bases to meet the Air Force's long-term objectives. From the military industrial base side, the Air Force would develop tactical/critical systems domestically to ensure those skills are maintained. On the commercial side, the Air Force would partner/procure other aircraft (e.g., strategic lift) from the commercial and/or international niche markets. The main advantage of this approach is that the Air Force can leverage existing commercial or commercial derivative developments and conserve RDT&E funding for critical systems.
- **International Partnering.** This approach would develop and produce new systems cooperatively with international partners where technology permits. It would be similar to the approach taken with the F-35 and Eurofighter. The advantages are that it helps defray some of the U.S. development expenses. However, such partnering is risky and there are major impediments to successful execution.³
- **Evolutionary Focus.** This strategy would develop upgrades to existing aircraft (i.e., the next series of a type), rather than introduce all new systems. This option emphasizes procurement with some RDT&E spending. It is similar to the Navy's approach with the F-18.
- **Maintain Force Levels.** This option focuses on sustainment of existing aircraft as well as building more of the current systems. Limited RDT&E spending would aim to develop ways to reduce O&M costs. This option would also extend the life of existing aircraft to maintain force levels.

Figure 4.1 shows the spending trade-offs for the six options. Each dimension (or axis) for the diagram shows the relative importance of that area of spending on a scale of 1 to 10, with 10 being most important. For example, the "Maintain Technical Edge" option emphasizes RDT&E spending (8) with minimal new procurement (3). The "Hedging Strategy" is a mix between RDT&E and sustainment spending, again deemphasizing new procurement. The "Evolutionary Focus Strategy" emphasizes new procurement while minimizing RDT&E and other sustainment spending. The options cover a range of trade-offs among RDT&E, procurement, and sustainment spending—where the more realistic options lie. In increasing order of emphasis on procurement, they are Maintain Technical Edge, Hedging Strategy, Hybrid Strategy, International Partnering, Evolutionary Focus, and Maintain Force Levels.

Table 4.1 lists the advantages and disadvantages for each option. No one strategy can meet all needs. Again, it is a choice between more capability now versus more capability in the future.

³ See John Birkler, Mark Lorell, and Michael Rich, *Formulating Strategies for International Collaboration in Developing and Producing Defense Systems*, Santa Monica, Calif.: RAND Corporation, IP-161, 1997.

Table 4.1. Advantages and Disadvantages of Strategic Funding Options

Investment Option	Pros	Cons
Maintain Technical Edge	<ul style="list-style-type: none"> • Future technical superiority • Fosters innovation 	<ul style="list-style-type: none"> • Greatly reduced force size as aging fleet not replaced • Price escalation • Cost and schedule risk • Small numbers procured • Greater O&M costs
Hedging Strategy	<ul style="list-style-type: none"> • Keeps industrial base focus on innovation • New firms may enter market 	<ul style="list-style-type: none"> • Will not support force structure modernization • Exacerbates aging issue
Hybrid Strategy	<ul style="list-style-type: none"> • Leverage international/commercial market for lower-end systems • Focus RDT&E spending 	<ul style="list-style-type: none"> • Relies on others to develop and direct improvements • Some skills and capabilities might move offshore • May meet with political resistance
International Partnering	<ul style="list-style-type: none"> • Greater integration with partners • Possible reduction in development and unit production costs 	<ul style="list-style-type: none"> • Ability of other nations to pay for systems not clear • Requirements will be a compromise between nations • Some skills and capabilities may move offshore in sharing arrangement • Potential loss of unique, U.S.-only technology • Greater management complexity
Evolutionary Focus	<ul style="list-style-type: none"> • Maintain current capabilities • Less cost escalation and risk 	<ul style="list-style-type: none"> • Risk of not being able to counter high-end threats • New firms may be frozen out of market
Maintain Force Levels	<ul style="list-style-type: none"> • Low cost and technical risk • Maintain current capabilities • Minimizes force size reduction 	<ul style="list-style-type: none"> • New firms may be frozen out of market • Exacerbates fleet aging issue • Risk of not being able to meet threats

Each of the investment options affects the AIB in different ways:⁴

- **Maintain Technical Edge:** This option keeps technical and design skills employed but may concentrate industry into sole sources due to fewer new programs and diminished production demand. The AIB may consolidate even further as a result.
- **Hedging Strategy:** Again, this moderately uses technical and design skills, including integration and airframe manufacturing capabilities, as does the Evolutionary Focus option. Production skills are not maintained at a level similar to other options. The Hedging Strategy option may allow smaller firms to enter market, however.
- **Hybrid Strategy:** This may result in some skills and production capabilities moving offshore. Congress might intervene to make this option unworkable. Again, the AIB may consolidate even further than it already has.
- **International Partnering:** Like the Hybrid Strategy, this option risks having some key skills and production capabilities move offshore. Congress might also intervene.
- **Evolutionary Focus:** This option moderately uses technical skills, but it does not use important skills such as integration and airframe development. Production capabilities are maintained but current suppliers/primes are locked in.
- **Maintain Force Levels:** With this option, important technical and design skills will atrophy. Again, the IB may consolidate even further due to lack of RDT&E funds.

The investment options emphasize different strategic objectives for both the Air Force and AIB. The five objectives we explored were

- an AIB that is innovative and a fleet that is highly capable.
- supporting a force structure that isn't rapidly declining.
- protecting technical skills in the AIB.
- protecting manufacturing skills in the AIB.
- supporting multiple primes in various commodity areas.

The Maintain Technical Edge option is the best at maintaining an AIB that has a high technical capability and is innovative, but it does not support the Air Force goal of maintaining a large force structure (due to curtailed procurement). At the other end of the spectrum, the Maintaining Force Levels option does support a significant fleet size and helps to preserve manufacturing skills, but it does so at the expense of an innovative AIB with strong technical skills (as a result of low RDT&E spending). This option also does

⁴ In examining the AIB, it is important to consider the technical (design and development) and production workforces *separately*. While both these workforces are necessary for a healthy industrial base, actions taken by the AF might have very different effects on each. For example, adding production units to an existing program might maintain production skills, but would do little to sustain technical skills. Likewise, prototyping efforts might sustain technical skills, but do little to sustain full-scale production skills. We examine the effects of the above investment options on the two workforces in Table 4.2.

not support having multiple primes for different aircraft types. The Hybrid Strategy moderately supports a number of AIB and Air Force priorities, but none very strongly. It represents the best option in terms of a compromise to all the priorities. The Evolutionary Focus, Hedging Strategy, and International Partnering options only support a few of the objectives and only one of them strongly. As we introduced in this section, the choice of an investment option will depend on the Air Force's long-term priorities. Trade-offs need to be made between having an innovative and high-tech Air Force versus one with significant force levels. Table 4.2 lists these priorities.

Table 4.2. Investment Strategy Choice Depends on Priorities

Investment Option	High Capability/ Innovative	Force Structure	Protects Industrial Base Technical Skills	Protects Industrial Base Manufacturing Skills	Multiple Primes
Maintain Technical Edge	XX		XX		X
Hedging Strategy	X		X		X
Hybrid Strategy	X	X	X	X	
International Partnering		X			X
Evolutionary Focus		X	X	XX	
Maintain Force Levels		XX		XX	

NOTE: One "X" indicates moderate support, two indicate stronger support.

5. Options and Potential Issues

Finally, we conclude with a summary of the options open to the Air Force and some other issues it may want to address.

As we introduced in the first section of this report, there are ongoing trends constraining the Air Force's ability to modernize. Regardless of the investment strategy selected, these issues need to be addressed to gain additional budget flexibility. One long-term trend we identify is the increasing unit procurement cost over the aircraft generations. With a real growth in cost of just over 4 percent per year, the ability of the Air Force to maintain significant force levels will be challenged.

Increasing O&M costs (e.g., cost per flying hour) also constrain the Air Force's budget flexibility. The cost per flying hour for newer generation aircraft is two to three times higher than older aircraft (see Figure A.2 in the Appendix).

While some of the investment options are more effective at helping the Air Force to maintain a technical edge, all the options could benefit from a harder look at research and development strategy and the force mix in terms of capability.

There are a number of mitigation steps that the Air Force could consider to counter these trends.

- To counter increasing procurement unit costs:
 - Increase research on production efficiency
 - Greater production competition/substitution
 - Explore force mix in terms of capability
 - Reduce overlap between EMD and production
 - Increase use of multiyear procurement
 - Scrub and better understand requirements vs. costs.
- To counter increasing O&M costs:
 - Choose most cost-effective mix of contractor/organic support
 - Focus more research and development on reducing O&M costs
 - Increase efficiency of AF support
 - More prototyping and other front-end activities to better define and control O&M costs.
- To maintain a technical edge:
 - Better integrate AF lab pursuits, internal research and development funds that the primes have, and other research and development

- Find other sources of innovation leverage
- Assess role of prototyping
- Assess role of force mix on capability.

There are some options for the Air Force to consider as it attempts to deal with problems in the industrial base caused by the budget decline. One potential way to offset some of the decline in domestic spending would be to increase international partnerships on programs. We've discussed some of the pros and cons of this strategy previously. In terms of implementing this approach, the Air Force will need to consider these questions:

- Who are those global partners, what are their needs, and what is their ability to pay? There are very few countries able to afford a fifth- or sixth-generation fighter. For those that can, are their requirements the same as those of the United States?
- How might export control rules and laws need to be revised? Are such revisions feasible within the time frames needed and political environment?
- How should the Air Force coordinate its industrial and RDT&E plans with other nations so that skills are available and there is no duplication of effort?

As discussed before, the preservation of skills and capabilities will be a challenge for the industrial base and Air Force during a downturn. As the Air Force develops strategies to mitigate this challenge, it should consider the following questions:

- What constitutes a core level of capability that must be preserved—both in terms of numbers and skills?
- What approaches are effective at mitigating work and funding shortfalls for these key skills?
- How can the industry and government ensure a continued supply of new talent?

One of the long-held tenets of U.S. defense acquisition is that competition fosters such benefits as innovation, affordable systems, and an efficient industrial base. With the industry facing another round of consolidation due to the downturn, competition for programs—at least at the prime level—might become infeasible if one or more of the current military aircraft primes exit the market. Also, the supplier base for military-unique capabilities may also decline to the point where there will be limited competition at the component level. This lack of competition will mean that the Air Force will have to pursue alternative incentives for cost control and innovation and become more involved in managing the industrial base.

We have explored a number of challenges facing the Air Force as it addresses issues of budget strategy with respect to aircraft spending during the current downturn and great uncertainty in congressional spending allocations. The current budget decline may not be like previous ones; the pattern of Air Force spending has shifted dramatically since the last downturn in the following ways:

- A greater proportion of procurement funds are being expended on non-aircraft programs.
- RDT&E budgets are at an all-time high for fixed-wing aircraft.
- Combat aircraft age is higher in this downturn than the last one, so the Air Force will have to either reduce force structure or continue spending more of its aircraft procurement funds on modifications of existing aircraft to maintain their relevance rather than newer ones.
- O&M spending for key newer aircraft is rising dramatically compared with older ones.
- Emergence of a competitor with significant technical and economic capability is another major difference from the previous downturn.

Therefore, there is a need for careful strategic management of investment choices—and this need goes beyond just aircraft. The Air Force will need to define its capability priorities that fit within budget constraints, then use those priorities to shape a budget strategy. As we've seen, a constrained spending future will result in challenges and issues for the industrial base. The Air Force will need to help mitigate industrial base problems that result from the budget strategy—but some issues may be beyond their control.

Finally, there are some lessons from the UK experience with submarines that the Air Force can leverage to avoid pitfalls. Most importantly, gaps in both industry and government skill bases can cause significant problems later during execution. Finding ways to sustain key skills during a gap will become important and potentially produce longer-term savings.

Finally, a few other observations that must be considered as the Air Force moves forward during the downturn in spending:

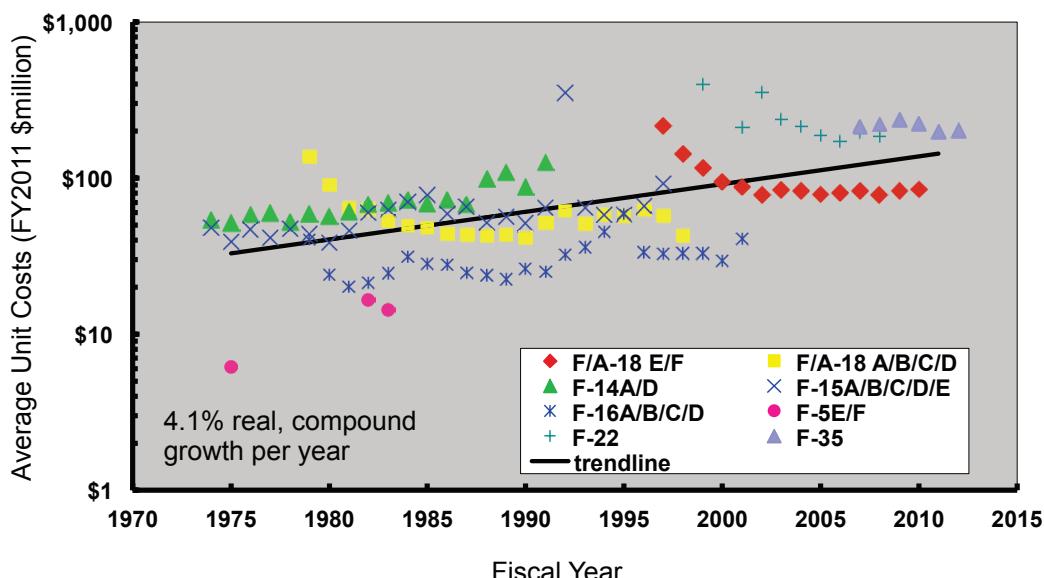
- The AIB could consolidate again, potentially morphing into sole sources (or sole-source teams) in many areas. This would require the Air Force to rethink how it works with industry and how it formulates acquisition strategy, as competition on individual programs might be infeasible.
- Military aircraft design and production requires unique skills not found in the commercial aircraft segment. While industry must manage these skills and has primary responsibility for them, the Air Force also has a critical role in protecting these skills. With few new program starts projected, RDT&E funds will be the primary lever the Air Force has to protect technical skills. The Air Force should consider devising a strategy that focuses the limited RDT&E likely to be available on technical areas that are not supported by commercial development.
- The Air Force needs to find a way to slow the progression of higher unit procurement costs and flying hour costs for new systems if it is going to be able to recapitalize/modernize effectively.

Appendix

Even After Adjusting for Inflation, Unit Costs for Military Aircraft Have Been Increasing Exponentially

Figure A.1 is an update to the Augustine proposition that weapon system cost increases over time far outpace general inflation.¹ It shows the average procurement unit costs for various fixed-wing tactical aircraft programs over the past four decades, adjusted to constant FY 2011 dollars using aircraft procurement Navy procurement deflators.² Each point represents the APUC for that particular fiscal year and program. The real APUC has increased nearly fivefold over this time frame. This increase equates to about a compounded, 4 percent annual increase above inflation.

Figure A.1. Unit Costs for Military Aircraft



Source: Office of the Under Secretary of Defense (Comptroller), "Procurement Programs(P-1)", Fiscal Years 1994 to 2010; Congressional Budget Office, *Total Quantities and Costs of Major Weapons Systems Procured: 1974-1993*, Washington, D.C., March 1992.

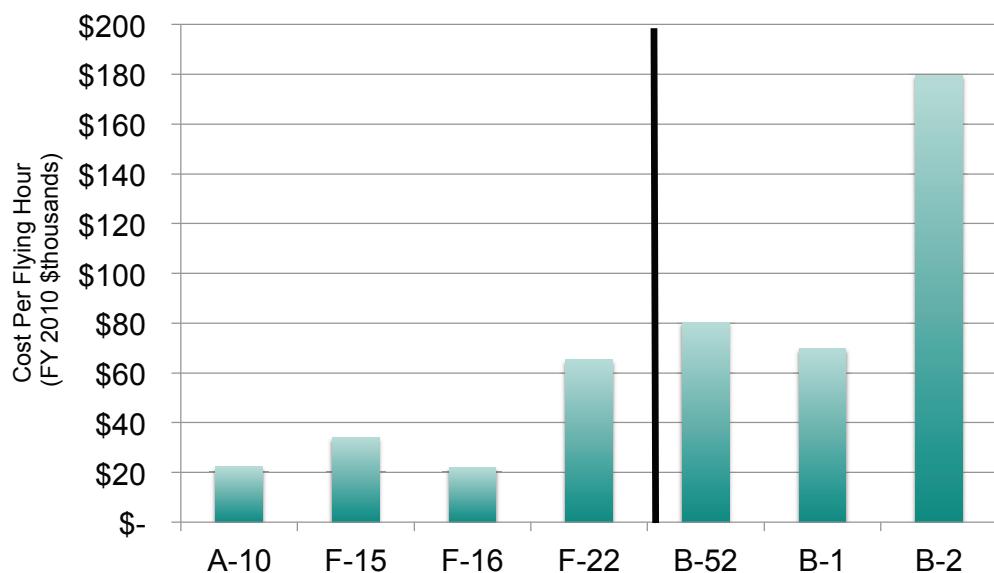
¹ Augustine, Norman R., *Augustine's Laws*, 6th ed., New York: Viking Penguin, 1997.

² Naval Center for Cost Analysis, "Joint Inflation Calculator" Development Version December 2009: Inflation Calculator for FY 2011 Budget, ver. 1, spreadsheet, January 2010.

This real price increase has significant implications for future affordability and fighter aircraft inventories. As prices increase faster than budgets rise, fewer aircraft can be purchased.

Figure A.2 shows the cost per flying hour for successive generations of fighters and bombers. The data were drawn from the Air Force Total Ownership Cost (AFTOC) database. The most recent models of each type (F-22 and B-2) are significantly more expensive to operate—two to three times higher—than previous models. The implications of this increase are that O&M budgets (on a per aircraft basis) will need to be higher as older aircraft retire and newer ones are introduced.

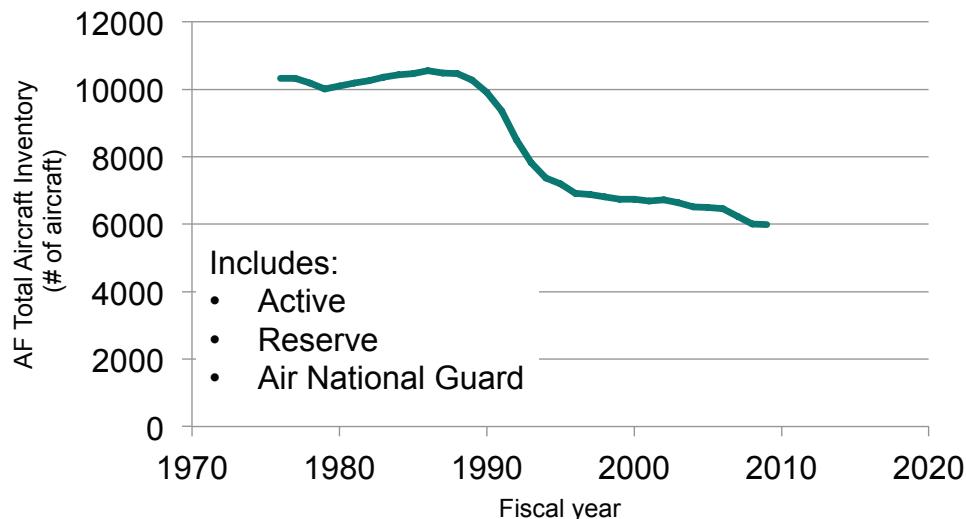
Figure A.2. Cost per Flying Hour Is Higher for Newer Aircraft



Source: AFTOC homepage, September 14, 2012.

One implication of the increasing unit cost and decline in the percent of overall procurement funding dedicated to new aircraft is that fewer new aircraft are being purchased than in previous years. This means there is no longer a one-for-one replacement. The result of this purchasing decline is a declining total aircraft inventory. Figure A.3 shows that the total inventory of Air Force aircraft has declined nearly 40 percent since the last downturn.

Figure A.3. Total Aircraft Inventory Has Declined by Nearly 40 Percent



Source: James C. Ruehrmund, Jr., and Christopher J. Bowie, *ARSENAL OF AIRPOWER: USAF Aircraft Inventory 1950-2009*, Mitchell Institute Study, November 2010.

Areas for Further Research

There are a number of areas where this research could be extended or further enhanced:

- **Examining options to preserve technical skills within the industrial base.** Technical skills are often the most difficult to preserve and technical workers often require advanced degrees and/or training. Moreover, certain skills require years of actual work experience to become proficient. Such research would assess the range of technical skills needed to develop a new, tactical aircraft and try to define a core level of capability such that potential new programs aren't hindered by a lack of skilled workers.
- **Develop an accepted set of metrics that define the health of the AIB.** As we discussed in this report, an accepted set of metrics does not currently exist. New research could explore a range of potential metrics (working with both government and industry) and identify the pros and cons of each. The goal would be to reduce the list of metrics to a handful that are useful and indicate potential problems.
- **Develop tools and models for better understanding of how changes in budget strategy (spending in different budget accounts) would affect future budgets and force structure.** Such research would require models that looked at not only procurement costs but operating and support costs, as well.
- **Explore the implications of one of the budget strategies in more depth.** Such research would need to quantitatively address what levels of spending would achieve the desired results and how future force levels would be affected.
- **Mitigate rates of growth.** The rate of increase in procurement and operating and maintenance costs for new aircraft is much higher than general inflation or the

rates of any projected budget increases. To be able to maintain force structure for the long-term, the Air Force must seek to mitigate these rates of growth. New research could explore the issues related to the growth and identify mitigation strategies.³

³ FY 2013 PAF research is examining the drivers of rising fixed-wing aircraft O&S costs.

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